

DYNAMIC CIRCUIT

BACKGROUND OF THE INVENTION

The present invention relates to a technique of reducing noise and noise-induced
5 operational failure in a dynamic circuit that uses MOS transistors.

Recently, in the field of semiconductor integrated circuits, process has been increasingly refined, enabling various advantages, such as high-speed operation, area saving, low power consumption and the like. With refined process, as low power supply voltage is necessary, it concurrently causes problems of noise immunity of a circuit.

10 Conventionally, a circuit called dynamic circuit has been used as one of the circuits for high-speed operation.

Fig. 15 illustrates an example of a conventional dynamic circuit.

Referring to Fig. 15, a reference numeral **101** denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor **101** is connected to a clock input terminal
15 **107**. When a clock signal **CK** from the clock input terminal **107** is Low ("Low" represents a ground voltage), a precharge node **112** is charged to High ("High" represents a power supply voltage). Reference numerals **102**, **103** and **104** denote N-type MOS transistors. The gate terminals of the N-type MOS transistors **102** to **104** are connected to input terminals **108** and **109** and the clock input terminal **107**, respectively, and the N-type MOS
20 transistors **102** and **103** are connected together via an intermediate node **113**. An input signal **A** from the input terminal **108** and an input signal **B** from the input terminal **109** fall in the Low period of the clock signal **CK**, and maintain at Low or rise in the High period thereof. A reference numeral **105** denotes an inverter that uses the precharge node **112** as an input, and an inversion output thereof is connected to an output terminal **111**. A
25 reference numeral **106** denotes a P-type MOS transistor that is conducted when an output

signal from the output terminal 111 is at Low, that is, when the precharge node 112 is at High, and the precharge node 112 is thereby maintained at High. The drivability of the P-type MOS transistor 106 is set lower than those of the N-type MOS transistors 102, 103 and 104. When the N-type MOS transistors 102, 103 and 104 are conducted, the precharge node 112 falls. Fig. 16 illustrates waveforms of signals of the dynamic circuit in Fig. 15.

Hereinafter, operation of the conventional dynamic circuit described above will be described.

First, the clock signal CK falls, the P-type MOS transistor 101 is conducted, and the precharge node 112 rises. Subsequently, when the clock signal CK rises, only when the input signals A and B rise, the ground terminal is conducted from the precharge node 112, and the precharge node 112 falls. The signal of the precharge node 112 is outputted to the output terminal 111 through the inverter 105. As such, the output signal falls in the Low period of the clock signal CK, and AND operation results of the input terminals 108 and 109 are outputted in the High period of the clock signal CK.

Fig. 17 illustrates another example of a conventional dynamic circuit.

The dynamic circuit of Fig. 17 differs from the dynamic circuit of Fig. 15 in that the N-type MOS transistor 104 is not provided. However, the other parts of the two dynamic circuits are same to each other, and the operations thereof are also similar to each other.

For example, as shown in Fig. 15, in the conventional dynamic circuit, when only the input signal A rises while the input signal B maintains at Low in the High period of the clock signal CK, only between the precharge node 112 and the intermediate node 113 is conducted. As such, when no charge is accumulated in the intermediate node 113, the charge in the precharge node 112 is shared to the intermediate node 113. Concurrently, the potential of the precharge node 112 approximately drops to the level of $\text{High} \cdot \{C_1 / (C_1 +$

C2)) from High, where C1 represents the capacitance of the precharge node 112 and C2 represents the capacitance of the intermediate node 113. Thereafter, the charge is supplied from the power supply through the P-type MOS transistor 106, returns the precharge node 112 to High. Fig. 16 shows waveforms of the operations described above.

5 As such, in the dynamic circuit including the intermediate node 113, noise is generated in some cases in the precharge node 112 depending on the combination of values of the input terminals. Due to the noise, it is possible that the noise immunity of the circuit is decreased or, in the worst case, the circuit can cause operational failure.

10 In order to solve the conventional problems, there is a method of enhancing the drivability of the P-type MOS transistor 106. In that case, the speed of turning the precharge node 112 into Low by the N-type MOS transistors 102, 103 and 104 is reduced, thereby impeding high-speed operation of the circuit.

SUMMARY OF THE INVENTION

15 An object of the present invention is to reduce noise due to charge sharing in a dynamic circuit.

20 Specifically, a dynamic circuit according to the present invention includes: a clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the clock input terminal; and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and a second potential power supply, and the precharge MOS transistor is conductive even after formation of a

25

conductive path from the intermediate node to the precharge node.

A dynamic circuit according to the present invention includes: a first clock input terminal; a second clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; a discharge MOS transistor connecting a source-drain path between a discharge node and a second potential power supply and connecting a gate terminal to the second clock input terminal; and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and the discharge node, and the precharge MOS transistor is conductive even after formation of a conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the clock input terminal connected to the gate terminal of the precharge MOS transistor is delayed so that the precharge MOS transistor is conducted even after the formation of the conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the clock input terminal connected to the gate terminal of the precharge MOS transistor is produced by performing a logical operation with signals applied to the input terminals so that the precharge MOS transistor is conducted even after the formation of the conductive path from the intermediate node to the precharge node.

According to the present invention described above, when the charge is shared from the precharge node to the intermediate node, the precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced.

Further, according to the present invention, when the charge is shared from the precharge node to the intermediate node, the precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, when the charge need not be supplied to the precharge node, the charge is not supplied thereto, thereby preventing the circuit operation speed from being reduced.

A dynamic circuit according to the present invention includes: a first clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and a second potential power supply. The dynamic circuit further includes: a second clock input terminal; and a precharge MOS transistor, different from the precharge MOS transistor, connecting the source-drain path between the first potential power supply and the precharge node and connecting the gate terminal to the second clock input terminal, wherein the different precharge MOS transistor is conductive from the time of formation of a conductive path from the intermediate node to the precharge node.

A dynamic circuit according to the present invention includes: a first clock input terminal; a second clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; a discharge MOS transistor connecting a source-drain path between a discharge node and a second potential power supply and connecting a gate terminal to the second clock input terminal;

and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and the discharge node. The dynamic circuit further includes: a third clock input terminal; and a precharge MOS transistor, different from the precharge MOS transistor, connecting a source-drain path between the first potential power supply and the precharge node and connecting a gate terminal to the third clock input terminal, wherein the different precharge MOS transistor is conductive from the time of formation of a conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the clock input terminal connected to the gate terminal of the different precharge MOS transistor is delayed so that the different precharge MOS transistor is conducted from the time of the formation of the conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the clock input terminal connected to the gate terminal of the different precharge MOS transistor is produced by performing a logical operation with signals applied to the input terminals so that the different precharge MOS transistor is conducted from the time of the formation of the conductive path from the intermediate node to the precharge node.

According to the present invention described above, when the charge is shared from the precharge node to the intermediate node, the different precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, by independently providing the two precharge MOS transistors, optimal charge effective for reducing noise due to the charge sharing can be supplied.

Further, when the charge is shared from the precharge node to the intermediate node, the precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, when the charge need not be supplied to the precharge node, the charge is not supplied thereto, thereby preventing the circuit operation speed from being reduced.

A dynamic circuit according to the present invention includes: a first clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and a second potential power supply. The dynamic circuit further includes: a second clock input terminal; and a precharge MOS transistor, different from the precharge MOS transistor, connecting a source-drain path between the first potential power supply and the precharge node and connecting a gate terminal to the second clock input terminal, wherein the different precharge MOS transistor is conductive even after formation of a conductive path from the intermediate node to the precharge node.

A dynamic circuit according to the present invention includes: a first clock input terminal; a second clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; a discharge MOS transistor connecting a source-drain path between a discharge node and a second potential power supply and connecting a gate terminal to the second clock input terminal;

and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and the discharge node. The dynamic circuit further includes: a third clock input terminal; and a precharge MOS transistor, different from the precharge MOS transistor, connecting a source-drain path between the first potential power supply and the precharge node and connecting a gate terminal to the third clock input terminal, wherein the different precharge MOS transistor is conductive even after formation of a conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the clock input terminal connected to the gate terminal of the different precharge MOS transistor is delayed so that the different precharge MOS transistor is conducted even after the formation of the conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the clock input terminal connected to the gate terminal of the different precharge MOS transistor is produced by performing a logical operation with signals applied to the input terminals so that the different precharge MOS transistor is conducted even after the formation of the conductive path from the intermediate node to the precharge node.

According to the present invention described above, when the charge is shared from the precharge node to the intermediate node, the different precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, when the precharge MOS transistor is conducted, the different precharge MOS transistor also can be conductive and the charge supply to the precharge node can be concurrently used for the different precharge MOS transistor. Hence, the size

of the precharge MOS transistor can be reduced. Further, when the charge is shared from the precharge node to the intermediate node, the precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, when the charge need not be supplied to the precharge node, the charge is not
5 supplied thereto, thereby preventing the circuit operation speed from being reduced.

A dynamic circuit according to the present invention includes: a clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the clock input terminal; and a plurality of logical-operating MOS
10 transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and a second potential power supply. The dynamic circuit further includes: precharge MOS transistors, different from
15 the precharge MOS transistor, smaller than the logical-operating MOS transistors in number, wherein gate terminals of the different precharge MOS transistors are connected to some of the plurality of input terminals, source-drain paths of the different precharge MOS transistors are connected between the first potential power supply and the precharge node, and the first potential power supply and the precharge node is conductive by the different
20 precharge MOS transistors in all cases where the precharge node and the second potential power supply is not conducted and the precharge node and the intermediate node is conducted by the logical-operating MOS transistors.

A dynamic circuit according to the present invention includes: a first clock input terminal; a second clock input terminal; a plurality of input terminals; a precharge MOS
25 transistor connecting a source-drain path between a first potential power supply and a

precharge node and connecting a gate terminal to the first clock input terminal; a discharge MOS transistor connecting a source-drain path between a discharge node and a second potential power supply and connecting a gate terminal to the second clock input terminal; and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and the discharge node. The dynamic circuit further includes: precharge MOS transistors, different from the precharge MOS transistor, smaller than the logical-operating MOS transistors in number, wherein gate terminals of the different precharge MOS transistors are connected to some of the plurality of input terminals, source-drain paths of the different precharge MOS transistors are connected between the first potential power supply and the precharge node, and the first potential power supply and the precharge node is conductive by the different precharge MOS transistors in all cases where the precharge node and the second potential power supply is not conducted and the precharge node and the intermediate node is conducted by the logical-operating MOS transistors.

According to the present invention described above, when the charge is shared from the precharge node to the intermediate node, the different precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, the noise reduction can be realized without an additional circuit for the clock signal.

A dynamic circuit according to the present invention includes: a first clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; and a plurality of logical-operating MOS

transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and a second potential power supply. The dynamic circuit further includes: a second clock input terminal; and at least one precharge MOS transistor, different from the precharge MOS transistor, connecting a source-drain path between the first potential power supply and the intermediate node and connecting a gate terminal to the second clock input terminal, wherein the different precharge MOS transistor is made conductive from the time of formation of a conductive path from the intermediate node to the precharge node.

A dynamic circuit according to the present invention includes: a first clock input terminal; a second clock input terminal; a plurality of input terminals; a precharge MOS transistor connecting a source-drain path between a first potential power supply and a precharge node and connecting a gate terminal to the first clock input terminal; a discharge MOS transistor connecting a source-drain path between a discharge node and a second potential power supply and connecting a gate terminal to the second clock input terminal; and a plurality of logical-operating MOS transistors, wherein gate terminals of the plurality of logical-operating MOS transistors are connected to one of the plurality of input terminals, respectively, and at least one intermediate node is formed to connect the source-drain paths of the plurality of logical-operating MOS transistors between the precharge node and the discharge node. The dynamic circuit further includes: a third clock input terminal; and a precharge MOS transistor, different from the precharge MOS transistor, connecting a source-drain path between the first potential power supply and the intermediate node and connecting a gate terminal to the third clock input terminal, wherein the different precharge MOS transistor is conductive from the time of formation of a

conductive path from the intermediate node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the second clock input terminal is delayed so that the different precharge MOS transistor is conducted from the time of the formation of the conductive path from the intermediate
5 node to the precharge node.

In the dynamic circuit according to the present invention, a clock signal applied to the second clock input terminal is produced by performing a logical operation with signals applied to the input terminals so that the different precharge MOS transistor is conducted from the time of the formation of the conductive path from the intermediate node to the
10 precharge node.

According to the present invention described above, when the charge is shared from the precharge node to the intermediate node, the different precharge MOS transistor supplies the charge to the intermediate node, so that noise due to charge sharing can be reduced. In addition, in a dynamic circuit including a plurality of intermediate nodes, by
15 providing the different precharge MOS transistor in each intermediate node, optimal charge effective for reducing noise due to the charge sharing can be supplied. Further, when the charge is shared from the precharge node to the intermediate node, the precharge MOS transistor supplies the charge to the precharge node, so that noise due to charge sharing can be reduced. In addition, when the charge need not be supplied to the precharge node, the
20 charge is not supplied thereto, thereby preventing the circuit operation speed from being reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a circuit diagram of dynamic circuits according to first and fourth
25 embodiments of the present invention.

Fig. 2 is a circuit diagram of a clock-signal generation circuit of the dynamic circuit according to the first embodiment and a dynamic circuit according to the second embodiment of the present invention.

Fig. 3 is a waveform diagram of signals of respective sections of the dynamic
5 circuits according to the first, second and fourth embodiments of the present invention.

Fig. 4 is a circuit diagram of the dynamic circuit according to the second embodiment of the present invention.

Fig. 5 is a circuit diagram of a dynamic circuit according to a third embodiment of the present invention.

10 Fig. 6 is a circuit diagram of a clock-signal generation circuit of the dynamic circuit according to the third embodiment of the present invention.

Fig. 7 is a waveform diagram of signals of respective sections of the dynamic circuit according to the third embodiment and a dynamic circuit according to a sixth embodiment of the present invention.

15 Fig. 8 is a circuit diagram of a clock-signal generation circuit of the dynamic circuit according to the fourth embodiment of the present invention.

Fig. 9 is a waveform diagram of signals of the respective sections of the dynamic circuit according to the fourth embodiment of the present invention.

Fig. 10 is a circuit diagram of a dynamic circuit according to a fifth embodiment
20 of the present invention.

Fig. 11 is a waveform diagram of signals of respective sections of the dynamic circuit according to the fifth embodiment of the present invention.

Fig. 12 is a circuit diagram of the dynamic circuit according to the sixth embodiment of the present invention.

25 Fig. 13 is a circuit diagram of a clock-signal generation circuit of the dynamic

circuit according to the sixth embodiment of the present invention.

Fig. 14 is another circuit diagram of the dynamic circuit according to the first embodiment of the present invention.

Fig. 15 is a circuit diagram of a conventional dynamic circuit.

5 Fig. 16 is a waveform diagram of signals of respective sections of the conventional dynamic circuit.

Fig. 17 is another circuit diagram of the conventional dynamic circuit.

DETAILED DESCRIPTION OF THE INVENTION

10 Hereinafter, dynamic circuits according to embodiments of the present invention will be described with reference to the drawings.

EMBODIMENT 1

Fig. 1 is a circuit diagram of a dynamic circuit according to a first embodiment of
15 the present invention. Referring to Fig. 1, a reference numeral 1 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 1 is connected to a second clock input terminal 10. A precharge node 12 is charged to High in the Low period of a second clock signal CKB from the second clock input terminal 10. Reference numerals 2 to 4 denote N-type MOS transistors. The gate terminals of the N-type MOS transistors 2 to 4
20 are connected to input terminals 8 and 9 and a first clock input terminal 7, respectively. The N-type MOS transistor 2 is connected to the N-type MOS transistor 3 via an intermediate node 13. An input signal A from the input terminal 8 and an input signal B from the input terminal 9 fall in the Low period of the first clock signal CKA from the first clock input terminal 7. The input signals A and B maintain at Low or rise in the High
25 period of the first clock signal CKA. Symbol "T1" represents an interval between when

the first clock signal **CKA** rises and when the input signal **A** rises. A reference numeral 5 denotes an inverter that uses a precharge node 12 as an input, and an inversion output thereof is connected to an output terminal 11. A reference numeral 6 denotes a P-type MOS transistor. When an output signal from the output terminal 11 is Low, that is, when the precharge node 12 is High, the P-type MOS transistor 6 is conducted and the precharge node 12 is thereby maintained at High. The drivability of the P-type MOS transistor 6 is set lower than that of each of the N-type MOS transistors 2 to 4. When the N-type MOS transistors 2 and 4 are conducted, the precharge node 12 falls.

Fig. 2 is a circuit that produces the first clock signal **CKA** and the second clock signal **CKB**. Referring to Fig. 2, a reference numeral 25 denotes an original clock input terminal. The first clock signal **CKA** and the second clock signal **CKB** are produced from an original clock signal **CKIN** from the original clock input terminal 25, and are outputted from output terminals 26 and 27, respectively. The output terminal 26 for the first clock signal **CKA** is connected to the first clock input terminal 7 in Fig. 1. The output terminal 27 for the second clock signal **CKB** is connected to the second clock input terminal 10 in Fig. 1. In Fig. 2, a reference numeral 21a denotes a buffer, and the delay from input to output is **T2**. **T2** is adjusted to satisfy the relation $T2 > T1$. A reference numeral 22a denotes an AND gate, and the delay from input to output is **T3**. A reference numeral 21b denotes a buffer, and the delay from input to output is **T3**, which is the same as that in the AND gate 22a. Fig. 3 is a waveform diagram of signals of the dynamic circuit in Figs. 1 and 2.

Operation of the above-configured dynamic circuit according to the first embodiment of the present invention will now be described hereinafter. In the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** from the original clock **CKIN**, the falling time of the first clock signal **CKA** is same as that of the second

clock signal **CKB**. However, the rising time of the second clock signal **CKB** is delayed for **T2** from that of the first clock signal **CKA**. First, the second clock signal **CKB** falls, the P-type MOS transistor **1** is conducted, and the precharge node **12** rises. Next, when the first clock signal **CKA** rises, only when the input signals **A** and **B** rise, the ground terminal is conducted from the precharge node **12** and the precharge node **12** falls. Herein, when only the input signal **A** rises and the input signal **B** maintains at Low, only between the precharge node **12** and the intermediate node **13** is conducted. When no charge is accumulated in the intermediate node **13**, the charge in the precharge node **12** is shared to the intermediate node **13**. However, since the second clock signal **CKB** rises after rise of the input signal **A**, even when the charge in the precharge node **12** is shared to the intermediate node **13**, the charge is supplied to the precharge node **12** via the P-type MOS transistor **1**. As such, the voltage drop of the precharge node **12** can be suppressed smaller than the conventional example (the precharge-node waveform in the conventional example is shown with a broken line in Fig. 3).

As described above, the first embodiment can reduce noise due to charge sharing of the precharge node **12**.

EMBODIMENT 2

Fig. 4 is a circuit diagram of a dynamic circuit according to a second embodiment of the present invention. Referring to Fig. 4, a reference numeral **1** denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor **1** is connected to a first clock input terminal **7**. A precharge node **12** is charged to High in the Low period of a first clock signal **CKA** from the first clock input terminal **7**. Reference numerals **2** to **4** denote N-type MOS transistors. The gate terminals of the N-type MOS transistors **2** to **4** are connected to input terminals **8** and **9** and the first clock input terminal **7**, respectively. The

N-type MOS transistor 2 is connected to the N-type MOS transistor 3 via an intermediate node 13. An input signal **A** from the input terminal 8 and an input signal **B** from the input terminal 9 fall in the Low period of the first clock signal **CKA** from the first clock input terminal 7. The input signals **A** and **B** maintain at Low or rise in the High period of the first clock signal **CKA**. Symbol "T1" represents an interval between when the first clock signal **CKA** rises and when the input signal **A** rises. A reference numeral 5 denotes an inverter that uses a precharge node 12 as an input, and an inversion output thereof is connected to an output terminal 11. A reference numeral 6 denotes a P-type MOS transistor. When an output signal from the output terminal 11 is Low, that is, when the precharge node 12 is High, the P-type MOS transistor 6 is conducted and the precharge node 12 is thereby maintained at High. The drivability of the P-type MOS transistor 6 is set lower than the drivability of each of the N-type MOS transistors 2 to 4. When the N-type MOS transistors 2 to 4 are conducted, the precharge node 12 falls. A reference numeral 14 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 14 is connected to the second clock input terminal 10. In the Low period of the second clock signal **CKB** from the second clock input terminal 10, the charge is supplied to the precharge node 12.

In the second embodiment, the clock-signal generation circuit is the same as that of the first embodiment. Also the waveforms of the signal of the dynamic circuit are the same as those of the first embodiment in Fig. 3.

Operation of the above-configured dynamic circuit according to the second embodiment of the present invention will now be described hereinafter. In the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** from the original clock **CKIN**, the falling time of the first clock signal **CKA** is same as that of the second clock signal **CKB**. However, the rising time of the second clock signal **CKB** is delayed

for T2 from that of the first clock signal CKA. First, the first clock signal CKA and the second clock signal CKB fall, the P-type MOS transistors 1 and 14 are conducted, and the precharge node 12 rises. Next, when the first clock signal CKA rises, only when the input signals A and B rise, the ground terminal is conducted from the precharge node 12 and the precharge node 12 falls. Herein, when only the input signal A rises and the input signal B maintains at Low, only between the precharge node 12 and the intermediate node 13 is conducted. When no charge is accumulated in the intermediate node 13, the charge in the precharge node 12 is shared to the intermediate node 13. However, since the second clock signal CKB rises after the rise of the input signal A, even when the charge in the precharge node 12 is shared to the intermediate node 13, the charge is supplied to the precharge node 12 via the P-type MOS transistor 14. As such, the voltage drop of the precharge node 12 can be suppressed smaller than the conventional example (the precharge-node waveform in the conventional example is shown with the broken line in Fig. 3).

As described above, the second embodiment can reduce noise due to charge sharing of the precharge node 12. In addition, as a P-type MOS transistor 1 to precharge in the Low period of the first clock signal CKA and another P-type MOS transistor 14 to reduce noise due to charge sharing are independently provided, the size of that P-type MOS transistor 14 can be optimized to reduce the noise. As such, the embodiment enables optimal charge supply effective for the noise reduction. Further, in the Low period of the first clock signal CKA, since the second clock signal CKB is also Low, the P-type MOS transistor 14 can be shared as a transistor for driving the precharge node 12 to High, the size of the P-type MOS transistor 1 can be reduced.

EMBODIMENT 3

Fig. 5 is a circuit diagram of a dynamic circuit according to a third embodiment of

the present invention. Referring to Fig. 5, a reference numeral 1 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 1 is connected to a first clock input terminal 7. A precharge node 12 is charged to High in the Low period of a first clock signal **CKA** from the first clock input terminal 7. Reference numerals 2 to 4, 32, and 33 denote N-type MOS transistors. The gate terminals of the N-type MOS transistors 2 to 4, 32, and 33 are connected to input terminals 8 and 9, the first clock input terminal 7, and input terminals 38 and 39, respectively. The N-type MOS transistor 2 is connected to the N-type MOS transistor 3 via an intermediate node 13. The N-type MOS transistor 32 is connected to the N-type MOS transistor 33 via an intermediate node 43. An input signal **A** from the input terminal 8, an input signal **B** from the input terminal 9, an input signal **C** from the input terminal 38, and an input signal **D** from the input terminal 39 fall in the Low period of the first clock signal **CKA** from the first clock input terminal 7. The input signals **A**, **B**, **C** and **D** maintain at Low or rise in the High period of the first clock signal **CKA**. Symbol "T1" represents an interval between when the first clock signal **CKA** rises and when the input signal **A** rises, and symbol "T4" represents an interval between when the first clock signal **CKA** rises and when the input signal **C** rises. A reference numeral 5 denotes an inverter that uses a precharge node 12 as an input, and an inversion output thereof is connected to an output terminal 11. A reference numeral 6 denotes a P-type MOS transistor. When an output signal from the output terminal 11 is Low, that is, when the precharge node 12 is High, the P-type MOS transistor 6 is conducted and the precharge node 12 is thereby maintained at High. The drivability of the P-type MOS transistor 6 is set lower than that of each of the N-type MOS transistors 2 to 4, 32, and 33. When the ground terminal is conducted from the precharge node 12 by the N-type MOS transistors 2 to 4, 32, and 33, the precharge node 12 falls. A reference numeral 14 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 14 is connected to the

second clock input terminal 10. In the Low period of the second clock signal **CKB** from the second clock input terminal 10, the charge is supplied to the precharge node 12. A reference numeral 34 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 34 is connected to a third clock input terminal 30. In the Low period of a third clock signal **CKC** from the third clock input terminal 30, the charge is supplied to the precharge node 12.

Fig. 6 is a circuit that produces the first clock signal **CKA**, the second clock signal **CKB** and the third clock signal **CKC** in Fig. 5. Referring to Fig. 6, a reference numeral 25 denotes an original clock input terminal. The first clock signal **CKA**, the second clock signal **CKB** and the third clock signal **CKC** are produced from an original clock signal **CKIN** from the original clock input terminal 25, and are outputted from output terminals 26 to 28, respectively. The output terminal 26 for the first clock signal **CKA** is connected to the first clock input terminal 7 in Fig. 5. The output terminal 27 for the second clock signal **CKB** is connected to the second clock input terminal 10 in Fig. 5. The output terminal 28 for the third clock signal **CKC** is connected to the third clock input terminal 30 in Fig. 5. In Fig. 6, a reference numeral 21c denotes a buffer, and the delay from input to output is **T3**. A reference numeral 23a denotes an inverter, and the delay from input to output is **T2**. A reference numeral 22b denotes an AND gate, and the delay from input to output is **T3**, which is the same as in the buffer 21c. A reference numeral 23b denotes an inverter, and the delay from input to output is adjusted to be **T1**. A reference numeral 23c denotes an inverter, and the delay from input to output is **T5**. A reference numeral 22c denotes an AND gate, and the delay from input to output is **T3**, which is the same as in the buffer 21c. A reference numeral 23d denotes an inverter, and the delay from input to output is adjusted to be **T4**. Fig. 7 is a waveform diagram of signals of the dynamic circuit shown in Figs. 5 and 6.

Operation of the above-configured dynamic circuit according to the third embodiment of the present invention will now be described hereinafter. In the circuit for producing the first, second and third clock signals **CKA**, **CKB** and **CKC** from the original clock **CKIN**, the second clock signal **CKB** falls after the rise of the first clock signal **CKA** with a time interval of **T1**, and rises thereafter with a further time interval of **T2**. The third clock signal **CKC** falls after the rise of the first clock signal **CKA** with a time interval of **T4**, and rises thereafter with a further time interval of **T5**. First, the first clock signal **CKA** falls, the P-type MOS transistor **1** is conducted, and the precharge node **12** rises. Next, when the first clock signal **CKA** rises, only when the input signal **A** and the input signal **B** rise or only when the input signal **C** and **D** rise, the ground terminal is conducted from the precharge node **12** and the precharge node **12** falls. Herein, when only the input signal **A** rises and the input signals **B**, **C** and **D** maintain at Low, only between the precharge node **12** and the intermediate node **13** is conducted. When no charge is accumulated in the intermediate node **13**, the charge in the precharge node **12** is shared to the intermediate node **13**. However, since the second clock signal **CKB** falls synchronized with the rise of the input signal **A**, even when the charge in the precharge node **12** is shared to the intermediate node **13**, the charge is supplied to the precharge node **12** via the P-type MOS transistor **14**. As such, the voltage drop of the precharge node **12** can be suppressed smaller than the conventional example (the precharge-node waveform in the conventional example is shown with a broken line in Fig. 7). In addition, when only the input signal **C** rises and the input signal **A**, **B** and **D** maintain at Low, only between the precharge node **12** and the intermediate node **43** is conducted. When no charge is accumulated in the intermediate node **43**, the charge in the precharge node **12** is shared to the intermediate node **43**. However, since the third clock signal **CKC** falls synchronized with the rise of the input signal **C**, even when the charge in the precharge node **12** is shared to the intermediate

node 43, the charge is supplied to the precharge node 12 via the P-type MOS transistor 34. As such, the voltage drop of the precharge node 12 can be suppressed smaller than the conventional example.

As described above, the third embodiment can reduce noise due to charge sharing of the precharge node 12 than the dynamic circuit of the conventional example. In addition, as a P-type MOS transistor 1 to precharge in the Low period of the first clock signal CKA and other P-type MOS transistors 14 and 34 to reduce noise due to charge sharing are provided, the sizes of the P-type MOS transistors 14 and 34 can be optimized to reduce the noise. As such, the embodiment enables optimal charge supply effective for the noise reduction. Further, P-type MOS transistors 14 and 34 are respectively provided for the intermediate nodes 13 and 43 to reduce noise due to charge sharing, and the sizes of the P-type MOS transistors 14 and 34 can be optimized to reduce the noise due to the charge sharing. As such, the embodiment enables optimal charge supply effective for the noise reduction for a plurality of charge sharing.

EMBODIMENT 4

A dynamic circuit according to a fourth embodiment of the present invention is the same as that of the first embodiment. In this embodiment, however, the time interval between the rise of the first clock signal CKA and the rise of the input signal A is T1 and the time interval between the rise of the first clock signal CKA and the rise of the input signal B is T4 to satisfy the relationship $T4 < T1$.

Fig. 8 is a circuit for producing the first clock signal CKA and second clock signal CKB in Fig. 1. Referring to Fig. 8, a reference numeral 25 denotes an original clock input terminal. The first clock signal CKA and the second clock signal CKB are produced from an original clock signal CKIN from the original clock input terminal 25 and an input

signal **B** from an input terminal 29. An output terminal 26 for the first clock signal **CKA** is connected to the first clock input terminal 7 in Fig. 1. An output terminal 27 for the second clock signal **CKB** is connected to the second clock input terminal 10 in Fig. 1. The input terminal 29 is connected to the input terminal 9 in Fig. 1. A reference numeral 21d denotes a buffer, and the delay from input to output is T_2 . T_2 is adjusted to satisfy the relation $T_2 > T_1$. A reference numeral 22d denotes an AND gate, and the delay from input to output is T_5 . A reference numeral 24 denotes an OR gate 24, and the delay from input to output is T_6 . T_6 is adjusted to satisfy the relations $T_5 + T_6 = T_3$ and $T_4 + T_6 < T_1$. A reference numeral 21e denotes a buffer, and the delay from input to output is T_3 .

Figs. 3 and 9 are waveform diagrams of signals of the dynamic circuits in Figs. 1 and 8.

Operation of the above-configured dynamic circuit according to the fourth embodiment of the present invention will now be described hereinafter. In the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** from the original clock **CKIN**, the falling time of the first clock signal **CKA** is same as that of the second clock signal **CKB**. For rising, when the input signal **B** maintains at Low after the change of the first clock signal **CKA**, the second clock signal **CKB** is delayed by T_2 . When the input signal **B** rises after the change of the first clock signal **CKA**, the second clock signal **CKB** is delayed by $(T_4 + T_6)$. First, the second clock signal **CKB** falls, the P-type MOS transistor 1 is conducted, and the precharge node 12 rises. Next, when the first clock signal **CKA** rises, only when the input signals **A** and **B** rise, the ground terminal is conducted from the precharge node 12 and the precharge node 12 falls. Herein, when only the input signal **A** rises and the input signal **B** maintains at Low, only between the precharge node 12 and the intermediate node 13 is conducted. When no charge is accumulated in the intermediate node 13, the charge in the precharge node 12 is shared to the intermediate node 13. However, since the second clock signal **CKB** rises after the rise

of the input signal **A**, even when the charge in the precharge node **12** is shared to the intermediate node **13**, the charge is supplied to the precharge node **12** via the P-type MOS transistor **1**. As such, the voltage drop of the precharge node **12** can be suppressed smaller than the conventional example (the precharge-node waveform in the conventional example is shown with a broken line in Fig. 3). When both the input signals **A** and **B** rise (waveforms are shown in Fig. 9), the second clock signal **CKB** rises prior to the rise of the input signal **A**. Hence, when the ground terminal has been conducted from the precharge node **12**, the P-type MOS transistor **1** is nonconductive, whereby the rise of the precharge node **12** is not impeded.

As described above, the fourth embodiment can reduce noise due to charge sharing of the precharge node **12** more than the dynamic circuit of the conventional example. In addition, in the fall of the precharge node **12**, the P-type MOS transistor **1** is not conducted. Therefore, the fall of the precharge node **12** is not impeded, consequently preventing delay from being increased.

EMBODIMENT 5

Fig. 10 is a circuit diagram of a dynamic circuit according to a fifth embodiment of the present invention. Referring to Fig. 10, a reference numeral **1** denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor **1** is connected to a clock input terminal **7'**. A precharge node **12** is charged to High in the Low period of a clock signal **CK** from the clock input terminal **7'**. Reference numerals **2** to **4** denote N-type MOS transistors. The gate terminals of the N-type MOS transistors **2** to **4** are connected to input terminals **8** and **9** and the clock input terminal **7'**. The N-type MOS transistor **2** is connected to the N-type MOS transistor **3** via an intermediate node **13**. An input signal **A** from the input terminal **8** and an input signal **B** from the input terminal **9** fall in the Low

period of the clock signal **CK** from the clock input terminal 7'. The input signals **A** and **B** maintain at Low or rise in the High period of the clock signal **CK**. A reference numeral 5 denotes an inverter that uses a precharge node 12 as an input, and an inversion output thereof is connected to an output terminal 11. A reference numeral 6 denotes a P-type MOS transistor. When an output signal from the output terminal 11 is Low, that is, when the precharge node 12 is High, the P-type MOS transistor 6 is conducted and the precharge node 12 is thereby maintained at High. The drivability of the P-type MOS transistor 6 is set lower than those of the N-type MOS transistors 2 to 4. When the N-type MOS transistors 2 to 4 are conducted, the precharge node 12 falls. A reference numeral 14 denotes a P-type MOS transistor that charges the precharge node 12 in the Low period of the input signal **B**. Fig. 11 illustrates waveforms of signals of the dynamic circuit in Fig. 10.

Operation of the above-configured dynamic circuit according to the fifth embodiment of the present invention will now be described hereinafter. First, the clock signal **CK** falls, the P-type MOS transistors 1 is conducted, and the precharge node 12 rises. Next, when the clock signal **CK** rises, only when the input signals **A** and **B** rise, the ground terminal is conducted from the precharge node 12 and the precharge node 12 falls. Herein, when only the input signal **A** rises and the input signal **B** maintains at Low, only between the precharge node 12 and the intermediate node 13 is conducted. When no charge is accumulated in the intermediate node 13, the charge in the precharge node 12 is shared to the intermediate node 13. However, when the input signal **B** maintains at Low, even when the charge in the precharge node 12 is shared to the intermediate node 13, the charge is supplied to the precharge node 12 via the P-type MOS transistor 14. As such, the voltage drop of the precharge node 12 can be suppressed smaller than the conventional example (the precharge-node waveform in the conventional example is shown with the

broken line in Fig. 11).

As described above, the fifth embodiment can reduce noise due to charge sharing of the precharge node 12 more than the dynamic circuit of the conventional example. Further, this can be realized without an additional circuit for the clock signals of the conventional dynamic circuit.

Further, in the fifth embodiment, noise is generated only a time when the input signal A rises and the input signal B remains at Low. However, since the precharge transistor 14 which is in ON state at the time is provided in this embodiment, no noise is generated.

EMBODIMENT 6

Fig. 12 is a circuit diagram of a dynamic circuit according to a sixth embodiment of the present invention. Referring to Fig. 12, a reference numeral 1 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 1 is connected to a first clock input terminal 7. A precharge node 12 is charged to High in the Low period of a first clock signal CKA from the first clock input terminal 7. Reference numerals 2 to 4 denote N-type MOS transistors. The gate terminals of the N-type MOS transistors 2 to 4 are connected to input terminals 8 and 9 and the first clock input terminal 7. The N-type MOS transistor 2 is connected to the N-type MOS transistor 3 via an intermediate node 13. An input signal A from the input terminal 8 and an input signal B from the input terminal 9 fall in the Low period of the first clock signal CKA from the first clock input terminal 7. The input signals A and B maintain at Low or rise in the High period of the first clock signal CKA. Symbol "T1" represents an interval between when the first clock signal CKA rises and when the input signal A rises. A reference numeral 5 denotes an inverter that uses a precharge node 12 as an input, and an inversion output thereof is connected to an output

terminal 11. A reference numeral 6 denotes a P-type MOS transistor. When an output signal from the output terminal 11 is Low, that is, when the precharge node 12 is High, the P-type MOS transistor 6 is conducted and the precharge node 12 is thereby maintained at High. The drivability of the P-type MOS transistor 6 is set lower than those of the N-type MOS transistors 2 to 4. When the N-type MOS transistors 2 to 4 are conducted, the precharge node 12 falls. A reference numeral 14 denotes a P-type MOS transistor. The gate terminal of the P-type MOS transistor 14 is connected to the second clock input terminal 10. In the Low period of the second clock signal **CKB** from the second clock input terminal 10, the charge is supplied to the intermediate node 13.

Fig. 13 is a circuit that produces the first clock signal **CKA** and the second clock signal **CKB**. Referring to Fig. 13, a reference numeral 25 denotes an original clock input terminal. The first clock signal **CKA** and the second clock signal **CKB** are produced from an original clock signal **CKIN** from the original clock input terminal 25, and are outputted from output terminals 26 and 27, respectively. The output terminal 26 for the first clock signal **CKA** is connected to the first clock input terminal 7 in Fig. 12. The output terminal 27 for the second clock signal **CKB** is connected to the second clock input terminal 10 in Fig. 12. In Fig. 13, a reference numeral 21f denotes a buffer, and the delay from input to output is **T3**. A reference numeral 23e denotes an inverter, and the delay from input to output is **T2**. A reference numeral 22e denotes an AND gate, and the delay from input to output is **T3**, which is the same as in the buffer 21f. A reference numeral 23f denotes an inverter, and the delay from input to output is adjusted to **T1**. Waveforms of signals of the dynamic circuit are the same as those in the waveform diagram of Fig. 7.

Operation of the above-configured dynamic circuit according to the sixth embodiment of the present invention will now be described hereinafter. In the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** from the original

clock **CKIN**, the second clock signal **CKB** falls after the rise of the first clock signal **CKA** with a time interval of **T1**, and rises thereafter with a further time interval of **T2**. First, the first clock signal **CKA** falls, the P-type MOS transistor **1** is conducted, and the precharge node **12** rises. Next, when the first clock signal **CKA** rises, only when the input signals **A** and **B** rise, the ground terminal is conducted from the precharge node **12** and the precharge node **12** falls. Herein, when only the input signal **A** rises and the input signal **B** maintains at Low, only between the precharge node **12** and the intermediate node **13** is conducted. When no charge is accumulated in the intermediate node **13**, the charge in the precharge node **12** is shared to the intermediate node **13**. However, since the second clock signal **CKB** falls synchronized with the rise of the input signal **A**, even when the charge in the precharge node **12** is shared to the intermediate node **13**, the charge is supplied to the intermediate node **13** via the P-type MOS transistor **14**. As such, the voltage drop of the precharge node **12** can be suppressed smaller than the conventional example (the precharge-node waveform in the conventional example is shown with a broken line in Fig.

7).

As described above, the sixth embodiment can reduce noise due to charge sharing of the precharge node **12** more than the dynamic circuit of the conventional example. In addition, the embodiment can supply optimal charge effective for the noise reduction in a dynamic circuit with a plurality of intermediate nodes. This can be realized by providing independent P-type MOS transistors **14** to reduce noise due to charge sharing for the respective intermediate nodes **13**.

As described above, according to each of the first, second, and fourth to sixth embodiments, the dynamic circuit performs AND operations for the input terminals **A** and **B**. In addition, according to the third embodiment, the dynamic circuit performs OR operations for the results of AND operations of the input terminals **A** and **B** and the results

of AND operations for the input terminals **C** and **D**. However, as long as an intermediate node is formed, the number of input terminals, and the logical operations are not limited.

In each of the first to sixth embodiments, the N-type MOS transistor where the gate is connected to the clock signal is located at the ground terminal. However, the
5 transistor may be omitted.

In each of the first to sixth embodiments, the inverter and the P-type MOS transistor are connected to the output. However, they may be omitted, or alternatively, a different circuit may be used.

In each of the first to sixth embodiments, the dynamic circuit is arranged such that
10 the P-type MOS transistor causes the precharge node to rise, and N-type MOS transistors cause the precharge node to fall or to maintain at High. However, the dynamic circuit configuration may have a different arrangement. Specifically, the polarities of the power supply terminal and ground terminal, and the types of the P-type MOS transistor and N-type MOS transistor are changed. Thereby, the N-type MOS transistor is used to cause the
15 precharge node to fall, and the P-type MOS transistors are used to cause the precharge node to rise or to maintain at Low. A circuit employing this arrangement with respect to Fig. 1 is shown in Fig. 14.

In the first and second embodiments, the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** has the arrangement shown in Fig. 2.
20 However, the circuit arrangement may be modified as long as the second clock signal **CKB** rises after the rise of the input signal **A**.

In the third embodiment, the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** has the arrangement shown in Fig. 6. However, the circuit may be arranged as long as the second clock signal **CKB** falls at the time of the rise of the
25 input signal **A** and the third clock signal **CKC** falls at the time of the rise of the input

signal **C**. Further, a signal different from the original clock **CKIN** may be used to produce the second clock signal **CKB** and the third clock signal **CKC**.

In the fourth embodiment, the circuit for producing the first clock signal **CKA** and the second clock signal **CKB** has the arrangement shown in Fig. 8. However, the circuit
5 may be arranged as long as it satisfies that when the input signal **B** maintains at Low, the second clock signal **CKB** rises after the rising of the input signal **A**, and when the input signal **B** rises, the second clock signal **CKB** rises prior to the rise of the input signal **A**.

In the fifth embodiment, the P-type MOS transistor **14** is provided to reduce the noise due to the charge sharing to the intermediate node **13**. However, the circuit
10 configuration may be arranged as long as charge is supplied to the precharge node **12** at least in one of the cases where charge sharing to the intermediate node **13** take place.

Further, in the sixth embodiment, although the P-type MOS transistor **14** for supplying charge to the intermediate node **13** is provided, when a plurality of intermediate nodes **13** are provided, P-type MOS transistors for supplying charge to parts or all of the
15 intermediate nodes **13** may be provided.